1. A method for sensorlessly controlling the operation of a thermoacoustic device including a linear electrodynamic machine communicating with a load device, said method comprising the steps of:

providing a thermoacoustic device including a linear electrodynamic machine communicating with a load device through a piston;

setting electrical inputs to the electrodynamic machine, the electrical inputs including frequency and either voltage or current;

determining a voltage signal at an input of the electrodynamic machine;

determining a current signal at the input of the electrodynamic machine;

estimating a positional parameter of the piston using the voltage and current signals, the positional parameter being selected from the group consisting of displacement, velocity, and acceleration of the piston;

estimating a force parameter of the load device using the positional parameter and the current signal, the force parameter being selected from the group consisting of force and pressure on the piston;

using the positional parameter and the force parameter to determine at least one operating condition of the thermoacoustic device, the operating condition being the phase angle between the positional parameter and the force parameter;

determining a difference between the at least one operating condition and a desired operating condition; and

adjusting at least one electrical input to the electrodynamic machine so as to reduce the difference, the adjusted input being one of frequency, current, and voltage.

2. The method of claim 1, further comprising repeating the determining, estimating and adjusting steps until the difference between the at least one operating condition and the desired operating condition is minimized.

3. The method of claim 1, further comprising developing a mathematical model of the electrodynamic machine, the estimating steps comprising using the mathematical model to perform the estimating.

4. The method of claim 1, wherein determining the current signal comprises measuring the current signal and filtering the measured current signal.

5. The method of claim 4, wherein the step of measuring and filtering the current imposes a time delay on the current signal, the method further comprising the step of delaying the voltage signal by a time-delay substantially equal to the time delay on the current signal.

6. The method of claim 1, wherein determining the voltage signal comprises measuring the voltage signal and filtering the measured voltage signal.

7. The method of claim 6, wherein the step of measuring and filtering the voltage signal imposes a time delay on the voltage signal, the method further comprising the step of delaying the current signal by a time-delay substantially equal to the time delay on the voltage signal.

8. The method of claim 1, wherein the steps of determining the voltage and current signals comprise measuring the voltage and current signals and filtering the measured voltage and current signals.

9. The method of claim 8, wherein the filtering step comprises filtering the voltage and current signals using substantially identical filters.

10. The method of claim 1, wherein the desired operating condition is a 90 degree phase angle between the displacement of the piston and the pressure on the piston.

11. The method of claim 1, wherein the desired operating condition is an in-phase relationship between the velocity of the piston and the pressure on the piston.

12. The method of claim 1, further comprising the step of providing a control device wherein the control device performs the steps of:

determining a difference between the at least one operating condition and a desired operating condition; and

adjusting at least one electrical input to the electrodynamic machine so as to reduce the difference.

13. The method of claim 12, wherein the control device is a phase locked loop.

14. The method of claim 1, wherein the desired operating condition corresponds to an acoustic resonance of the thermoacoustic device.

15. The method of claim 1, further comprising setting limits on at least one of the electrical inputs, positional parameters or force parameters, the adjusting step comprising adjusting the at least one electrical input so as not to violate the at least one limit.

16. The method of claim 1, wherein the step of estimating the positional parameter comprises estimating the displacement, $\hat{x}$, of the piston according to equation

$$\hat{x} = \frac{1}{Bl}\left[\int (v_t - iR_e)dt - L_e i\right]$$

wherein Bl is the transduction coefficient,

v_t is the voltage signal at the terminals of the machine,

i is the current,

Re is the stator winding resistance, and

Le is the self inductance of the stator windings.

17. The method of claim 1, wherein the step of estimating the force parameter comprises estimating the pressure, $\hat{p}_a$, according to equation

$$\hat{p}_a = \frac{1}{A}\left(Bli - M_m \frac{d^2\hat{x}}{dt^2} - R_m \frac{d\hat{x}}{dt} - K_m \hat{x} \right).$$

wherein Bl is the transduction coefficient,

i is the current,

Mm is the actuator moving mass,

$\hat{x}$ is the estimated displacement of the piston,

Rm is the damping constant,

Km is the spring constant, and

A is the area of a piston in communication with the load device.

18. The method of claim 1, wherein the step of estimating the positional parameter comprises estimating the displacement, $\hat{x}$, of the piston according to equation

$$\hat{x} = \frac{1}{Bl}\left[\int \left(v_t - iR_e - \omega L_{imag}\, i\right)dt - L_e i + k_1 i^3 + k_2 i^5\right]$$

wherein Bl is the transduction coefficient,

v_t is the voltage signal at the terminals of the machine,

i is the current,

Re is the stator winding resistance,

L_{imag} is the imaginary component of the inductance of the windings,

ω is the operating frequency in radians/sec,

Le is the self inductance of the stator windings, and

k_1 and k_2 are small, non-complex constants.

19. A method for sensorlessly controlling the operation of a thermoacoustic device including a linear electrodynamic machine communicating with a load device, said method comprising the steps of:

providing a thermoacoustic device including a linear electrodynamic machine communicating with a load device through a piston;

setting electrical inputs to the electrodynamic machine, the electrical inputs including frequency and either voltage or current;

determining a voltage signal at an input of the electrodynamic machine;

determining a current signal at the input of the electrodynamic machine;

estimating a positional parameter of the piston using the voltage and current signals, the positional parameter being selected from the group consisting of displacement, velocity, and acceleration of the piston;

estimating a force parameter of the load device using the positional parameter and the current signal, the force parameter being selected from the group consisting of force and pressure on the piston;

using at least the positional parameter and the force parameter to determine at least one operating condition of the thermoacoustic device, the operating condition being selected from the group consisting of efficiency and power; and

adjusting at least one electrical input to the electrodynamic machine so as to maximize the operating condition, the adjusted input being one of frequency, current, and voltage.

20. The method of claim 19, further comprising repeating the determining, estimating and adjusting steps until the difference between the at least one operating condition and the desired operating condition is minimized.

21. The method of claim 19, further comprising developing a mathematical model of the electrodynamic machine, the estimating steps comprising using the mathematical model to perform the estimating.

22. The method of claim 19, wherein determining the current signal comprises measuring the current signal and filtering the measured current signal.

23. The method of claim 22, wherein the step of measuring and filtering the current imposes a time delay on the current signal, the method further comprising the step of delaying the voltage signal by a time-delay substantially equal to the time delay on the current signal.

24. The method of claim 19, wherein determining the voltage signal comprises measuring the voltage signal and filtering the measured voltage signal.

25. The method of claim 24, wherein the step of measuring and filtering the voltage signal imposes a time delay on the voltage signal, the method further comprising the step of delaying the current signal by a time-delay substantially equal to the time delay on the voltage signal.

26. The method of claim 19, wherein the steps of determining the voltage and current signals comprise measuring the voltage and current signals and filtering the measured voltage and current signals.

27. The method of claim 26, wherein the filtering step comprises filtering the voltage and current signals using substantially identical filters.

28. The method of claim 19, wherein the operating condition is power, the positional parameter is velocity, the force parameter is force, and the power is determined by multiplying the velocity by the force and time averaging the product over a cycle.

29. The method of claim 19, wherein the operating condition is efficiency, the positional parameter is velocity, and the force parameter is force, the operating condition determining step further using the voltage and current signals, the efficiency being determined by dividing the product of the force and velocity by the time averaged product of the voltage and current signals.

30. The method of claim 19, further comprising the step of providing a control device wherein the control device performs the step of

adjusting the at least one electrical input to the electrodynamic machine so as to maximize the operating condition.

31. The method of claim 19, further comprising setting limits on at least one of the electrical inputs, positional parameters or force parameters, the adjusting step comprising adjusting the at least one electrical input so as not to violate the limit.

32. The method of claim 19, wherein the step of estimating the positional parameter comprises estimating the velocity , $\hat{V}_{pist}$, of the piston according to equation

$$\hat{V}_{pist} = \frac{1}{Bl}\left(v_t - iR_e - L_e \frac{di}{dt}\right)$$

wherein Bl is the transduction coefficient,

v_t is the voltage signal at the terminals of the machine,

i is the current,

Re is the stator winding resistance, and

Le is the self inductance of the stator windings.

33. The method of claim 19, wherein the step of estimating the force parameter comprises estimating the force on the load, $\hat{f}_{load}$, according to equation

$$\hat{f}_{load} = Bli - M_m \frac{d\hat{V}_{pist}}{dt^2} - R_m \hat{V}_{pist} - K \int \hat{V}_{pist} dt$$

wherein Bl is the transduction coefficient,

i is the current,

Mm is the actuator moving mass,

$\hat{x}$ is the estimated displacement of the piston,

Rm is the damping constant,

Km is the spring constant, and

A is the area of a piston in communication with the load device.

34. The method of claim 19, wherein the step of estimating the positional parameter comprises estimating the displacement, $\hat{x}$, and the velocity, $\hat{V}_{pist}$ of the piston according to equations:

$$\hat{x} = \frac{1}{Bl}\left[\int \left(v_1 - iR_e - \omega L_{imag} i\right) dt - L_e i + k_1 i^3 + k_2 i^5\right]$$

and,

$$\hat{V}_{pist} = \frac{d\hat{x}}{dt}$$

wherein Bl is the transduction coefficient,

v_t is the voltage signal at the terminals of the machine,

i is the current,

Re is the stator winding resistance,

L_{imag} is the imaginary component of the inductance of the windings,

ω is the operating frequency in radians/sec,

Le is the self inductance of the stator windings, and

k_1 and k_2 are small, non-complex constants.

35. A method for sensorlessly controlling the operation of a system including a reciprocating linear electrodynamic machine harmonically driving a displaceable portion of a load device, said method comprising the steps of:

providing a system including a linear electrodynamic machine harmonically driving a displaceable portion of a load device;

setting electrical inputs to the electrodynamic machine, the electrical inputs including frequency and either voltage or current;

determining a voltage signal at an input of the electrodynamic machine;

determining a current signal at the input of the electrodynamic machine;

estimating a positional parameter of the load device using the voltage and current signals, the positional parameter being selected from the group consisting of displacement, velocity, and acceleration of the displaceable portion;

estimating a force parameter of the load device using the positional parameter and the current signal, the force parameter being selected from the group consisting of force and pressure;

using at least the positional parameter and the force parameter to determine at least one operating condition of the system, the operating condition being selected from the group consisting of efficiency, power, phase between the positional parameter and the force parameter, and a ratio between the positional parameter and the force parameter;

determining a difference between the operating condition and a desired operating condition; and

adjusting at least one electrical input to the electrodynamic machine so as to reduce the difference, the adjusted input being one of frequency, current, and voltage.

36. The method of claim 35, further comprising repeating the determining, estimating and adjusting steps until the difference between the at least one operating condition and the desired operating condition is minimized.

37. The method of claim 35, further comprising developing a mathematical model of the electrodynamic machine, the estimating steps comprising using the mathematical model to perform the estimating.

38. The method of claim 35, wherein the load device is a thermoacoustic device, and the desired operating condition is an acoustic resonance of the thermoacoustic device.

39. The method of claim 35, wherein determining the current signal comprises measuring the current signal and filtering the measured current signal.

40. The method of claim 39, wherein the step of measuring and filtering the current imposes a time delay on the current signal, the method further comprising the step of delaying the voltage signal by a time-delay substantially equal to the time delay on the current signal.

41. The method of claim 35, wherein determining the voltage signal comprises measuring the voltage signal and filtering the measured voltage signal.

42. The method of claim 41, wherein the step of measuring and filtering the voltage signal imposes a time delay on the voltage signal, the method further comprising the step of delaying the current signal by a time-delay substantially equal to the time delay on the voltage signal.

43. The method of claim 35, wherein the steps of determining the voltage and current signals comprise measuring the voltage and current signals and filtering the measured voltage and current signals.

44. The method of claim 43, wherein the filtering step comprises filtering the voltage and current signals using substantially identical filters.

45. The method of claim 35, wherein the desired operating condition is a 90 degree phase angle between the displacement and the pressure.

46. The method of claim 35, wherein the step of estimating the positional parameter comprises estimating the displacement, $\hat{x}$, according to equation

$$\hat{x} = \frac{1}{Bl}\left[\int(v_t - iR_e)dt - L_e i\right]$$

wherein *Bl* is the transduction coefficient,

v_t is the voltage signal at the terminals of the machine,

i is the current, *Re* is the stator winding resistance, and

Le is the self inductance of the stator windings.

47. The method of claim 35 wherein the step of estimating the force parameter comprises estimating the pressure, $\hat{p}_a$, according to equation

$$\hat{p}_a = \frac{1}{A}\left(Bli - M_m\frac{d^2\hat{x}}{dt^2} - R_m\frac{d\hat{x}}{dt} - K_m\hat{x}\right).$$

wherein *Bl* is the transduction coefficient,

i is the current,

Mm is the actuator moving mass,

$\hat{x}$ is the estimated displacement of the displaceable portion,

Rm is the damping constant,

Km is the spring constant, and

A is the area of the displaceable portion.

48. The method of claim 35, wherein the step of estimating the positional parameter comprises estimating the displacement, $\hat{x}$, of the piston according to equation

$$\hat{x} = \frac{1}{Bl}\left[\int\left(v_1 - iR_e - \omega L_{imag}\, i\right)dt - L_e i + k_1 i^3 + k_2 i^5\right]$$

wherein *Bl* is the transduction coefficient,

v_t is the voltage signal at the terminals of the machine,

i is the current,

Re is the stator winding resistance,

L_{imag} is the imaginary component of the inductance of the windings,

ω is the operating frequency in radians/sec,

Le is the self inductance of the stator windings, and

k_1 and k_2 and small, non-complex constants.

49. The method of claim 35, further comprising setting limits on at least one of the electrical inputs, positional parameters or force parameters, the adjusting step comprising adjusting the at least one electrical input so as not to violate the limit.

50. A method for controlling the operation of a system including a reciprocating linear electrodynamic machine harmonically driving a displaceable portion of a load device, said method comprising the steps of:

providing a system including a linear electrodynamic machine harmonically driving a displaceable portion of a load device;

setting electrical inputs to the electrodynamic machine, the electrical inputs including frequency and either voltage or current;

determining a current signal at the input of the electrodynamic machine;

determining a positional parameter of the load device, the positional parameter being selected from the group consisting of displacement, velocity, and acceleration of the displaceable portion;

estimating a force parameter of the load device using the positional parameter and the current signal, the force parameter being selected from the group consisting of force and pressure;

using at least the positional parameter and the force parameter to determine at least one operating condition of the system, the operating condition being selected from the group consisting of efficiency, power and phase between the positional parameter and the force parameter;

determining a difference between the operating condition and a desired operating condition; and

adjusting at least one electrical input to the electrodynamic machine so as to reduce the difference, the adjusted input being one of frequency, current, and voltage.

51. The method of claim 50, wherein the determining the positional parameter step comprises measuring the positional parameter.